SOI capacitively-transduced RF MEMS resonators for biosensing applications

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Introduction

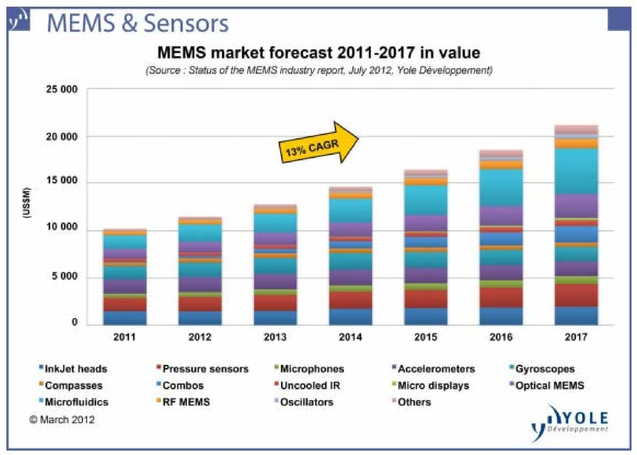
- High yield capacitive transduced RF MEMS resonators were built using SOI technology for mass sensing applications
- Air, refilled high K dielectric ,and fully solid high K dielectric gaps will be studied
- Highly selective functionalized MEMS biosensing platform using antibody-antigen interaction

Motivation

- Electrostatically transduced RF MEMS/NEMS Mechanical resonators have been widely used as mass sensors platforms
- High sensitivity and selectivity with a broad Limit of Detection make these devices ideal for biosensing applications
- MEMS/NEMS technology is one of the fasted growing industries worldwide

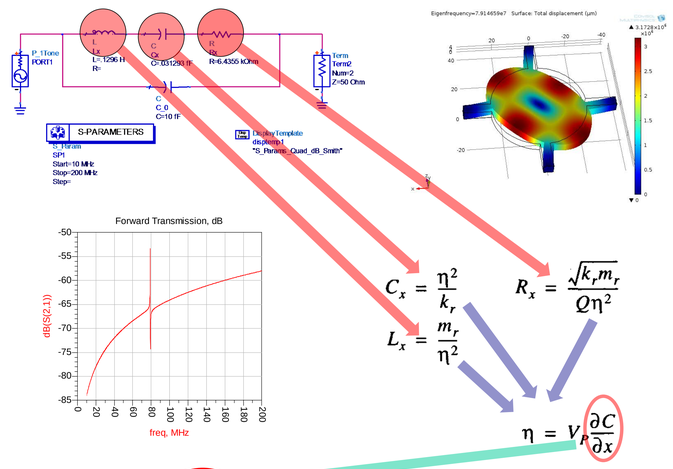
Advantages of MEMS/NEMS resonators over other competitive technology

	M/NEMS Resonator	Nanowires	Solid State Devices	QCM/SAW	Nano SPR
Read out accuracy	High	Medium	Medium	High	High
Limit of detection	ppt	ppt	ppb	ppb	ppb-ppt
Response time	sec	min	min	sec	sec
Manufacturability	YES	Hard	YES	YES	Hard
Miniaturization	YES	YES	YES	Hard	Hard



Simulation

- Using Coventorware, Advanced Design, MathLab, and COMSOL resonator values were approximated

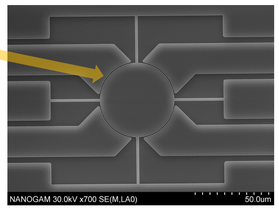


$$R_X = \frac{K_r}{v_p^2 w_o} * \frac{d_o^4}{A_o^2 \varepsilon_o^2 \varepsilon_r^2} * \frac{1}{Q(air\ gap)}$$

Ao: Electrode Area

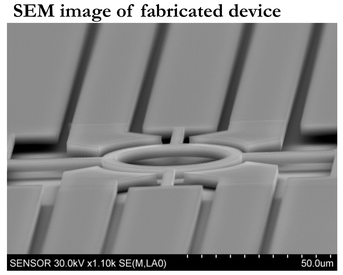
$\mathcal{E}r$: dielectric constant of the device

do: gap between the disk and electrode

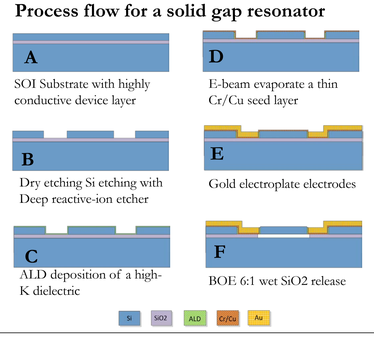


Fabrication

SEM image of fabricated device



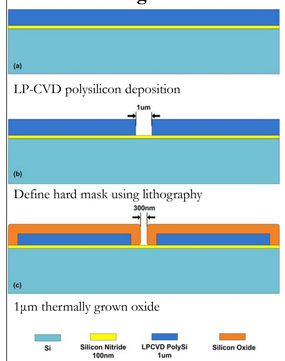
Process flow for a solid gap resonator



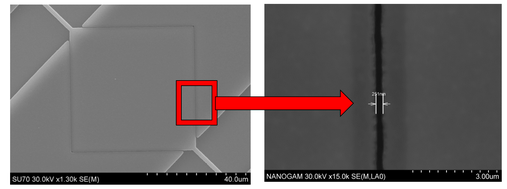
Gap reduction

- Gap reduction is crucial to reduce the characteristic impedance of the device
- Two methods were used: Oxidation and ALD deposition

Process flow of gap reduction using Oxidation

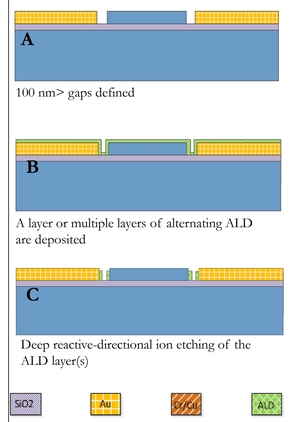


SEM images of oxidation gap reduction

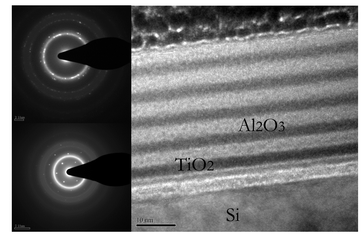


- Reproducible nano-gaps using conventional lithography
- Easy, low-cost and repeatable technique to create nanostructures

Process flow of gap reduction using ALD deposition



TEM image with diffraction pattern of multiple layers of ALD grown and characterized in USF



- Atomically controlled thickness
- Low temperature process (~100 C°)
- Very conformal process
- High K dielectric materials

Future Work

- Highly selective capacitive-transduced biosensor
- CMOS compatible biosensor
- Microfluidic Lab-in-a-chip biosensor

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